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REPORT OF INVESTIGATION

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Note: This report has not been edited to Utah Geological and Mineral Survey standards.

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UTAH GEOLOGICAL AND MINERAL SURVEY

REPORT OF INVESTIGATION NO. 184

MINING CONDITIONS AND PROBLEMS ENCOUNTERED WITHIN THE TEXASGULF-CANE CREEK POTASH MINE NEAR MOAB, UTAH; AND POTENTIAL MINING CONDITIONS AT GIBSON DOME, UTAH

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August, 1984

TABLE OF CONTENTS

ILLUSTRATIONS

MINING CONDITIONS AND PROBLEMS ENOUNTERED WITHIN THE TAXASGULF-CANE CREEK POSASH MINE NEAR MOAB, UTAH; AND POTENTIAL MINING CONDITIONS AT GIBSON DOME, UTAH

PURPOSE

The purpose of this report is to present a synopsis of some of the mining conditions encountered in the Texas Gulf-Cane Creek potash mine, and to relate them to the potential mining conditions at Gibson Dome.

INTRODUCTION

In 1964, Texas Gulf Sulfur Company, now Texasgulf, Inc., began mining potash from the Cane Creek anticline in southeastern Utah. The location of the mine is in T. 26 S., R. 20 E., as shown on figure 1, some 8 air miles southwest of the town of Moab, Utah.

This report is based on conversations concerning underground mining problems encountered by the firm that were held between Rudy Higgins, general manager, Dave Gahr, geologist, of the Texasgulf, Inc. Cane Creek potash mine, and the author on September 14, 1982. The final draft of this report was submitted in May, 1984.

The Cane Creek mine began as a conventional underground excavation in 1964, but was converted to a system combining solution mining and solar evaporation in 1970.

The potash ore, sylvinite, was mined from the K5 potash zone situated near the upper portion of Salt 5 of the thick Paradox Formation evaporite sequence. The stratigraphic position of marker bed 4, consisting of anhydrite, dolomite and shale, is immediately above the ore zone. The stratigraphy of the K5 potash zone and its relationship to marker bed 4 (Evans and Linn, 1970, p. 289) is shown in figure 2.

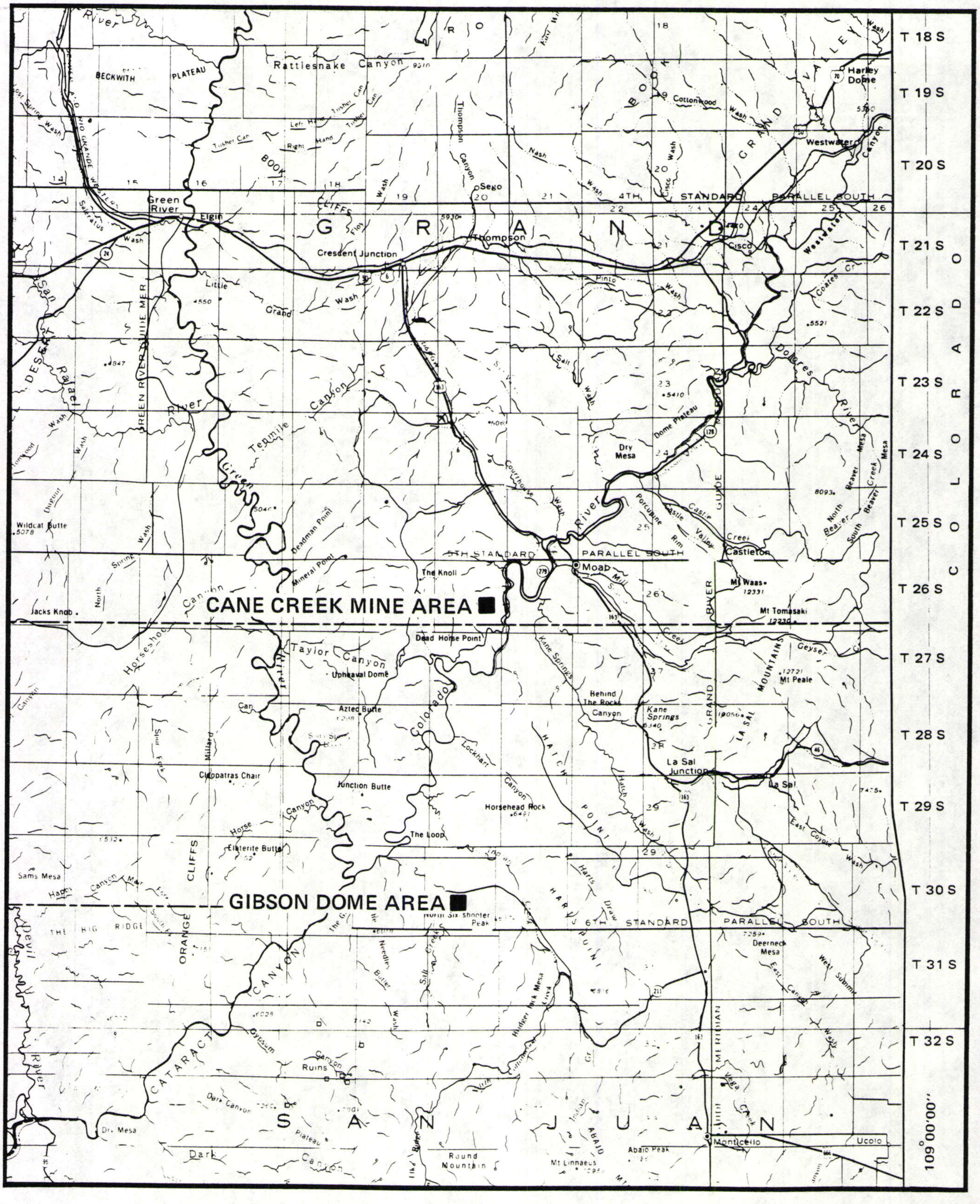

Figure 1. Showing the location of the Cane Creek study area and of the Gibson Dome area, Grand and San Juan Counties, Utah (map scale 1:000,000).

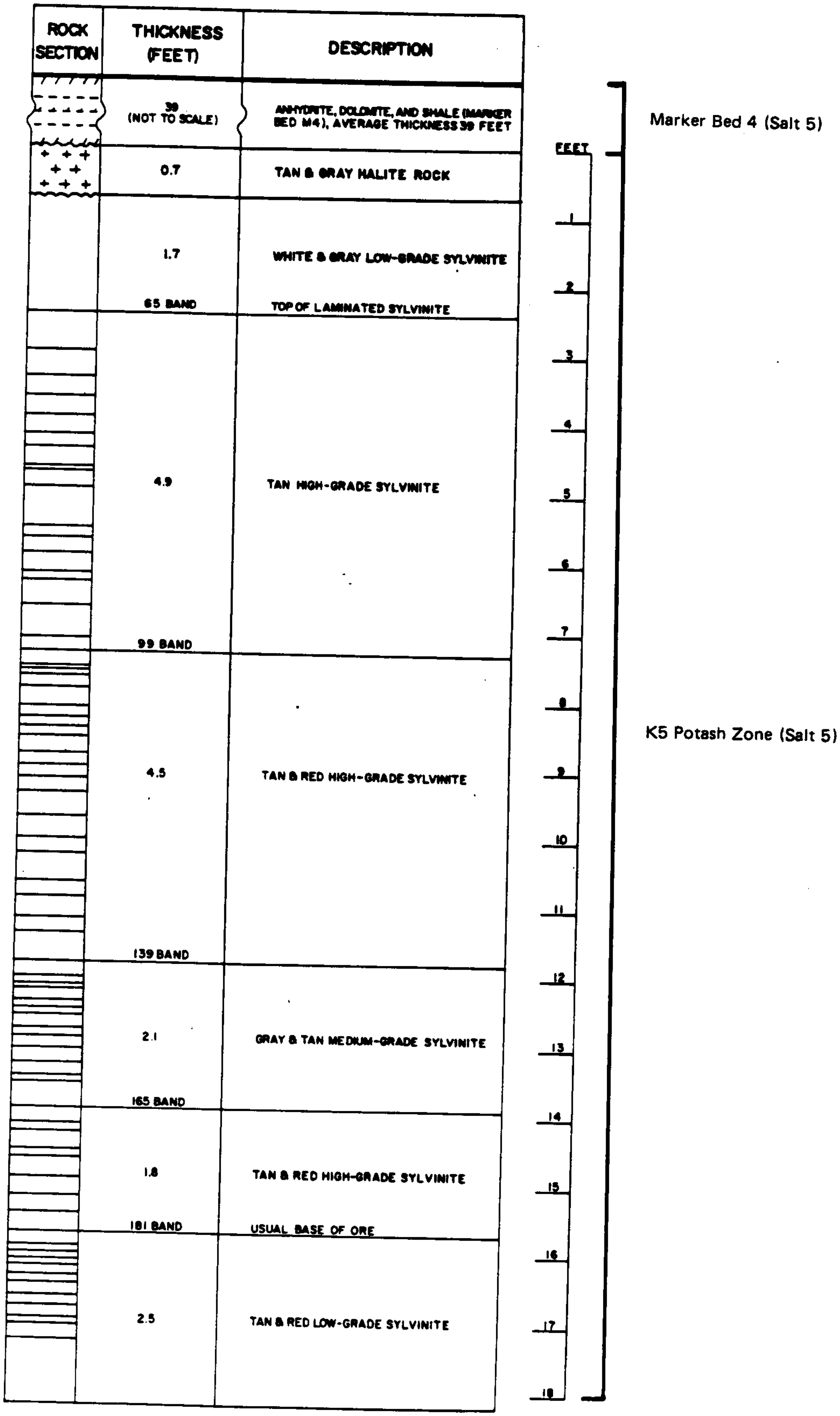

Figure 2. Stratigraphy of the K5 potash zone. Taken from Evans and Linn (1970, p. 289).

MINING CONDITIONS AT CANE CREEK

Mine Development

Access to the Salt 5 potash ore zone was made by driving the main shaft to a depth of approximately 2789 feet. From near the bottom of the shaft, an incline was driven into the ore zone proper as shown schematically in figure 3. The main shaft was 22 feet in diameter and the inclines were 8 feet high by 14 feet wide. A circular safety zone, with a radius of 2600 feet, was maintained around the shaft. No mining was done in the safety zone, with the exception of the inclines from the shaft to the ore zone.

The Cane Creek Mine workings were developed from the point where the incline entries penetrated the ore zone. Initially, mining was done by the room and pillar method; some 150 miles of underground workings were driven. As mining progressed, however, modifications were made to the strictly room and pillar method in response to changing conditions, such as the spatial attitude of the ore zone or the grade of the ore. Because of steep dips on the flanks of the anticline, mining operations were maintained near the top of the structure. The mine operated within a 500-foot vertical range from 2700 to 3200 feet below the surface.

Mining Problems in Sylvinite Ore

Secondary folding, the necessity of maintaining a salt roof in the workings, and salt movement were three of the main problems encountered during mining in the Cane Creek Mine.

Secondary Folding--The intense secondary folding, imprinted over the broad primary Cane Creek anticlinal structure, presented one of the major problems that was encountered while mining the K5 potash zone. A detailed analysis of primary, secondary and higher order fold relationships within the anticline is given by Evans and Linn (1970).

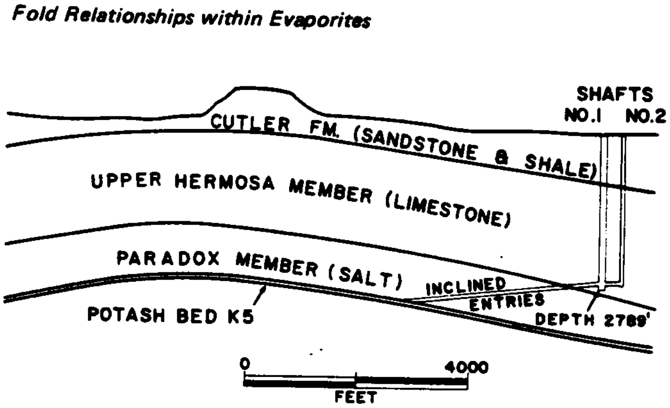

Figure 3. Schematic diagram showing the shaft and incline entry path into the ore zone. Taken from Evans and Linn (1970, p. 289).

The sylvinite from the K5 potash zone follows the intense secondary folding. The economic recovery of the sylvinite required that the ore zone be followed precisely. Because of this undulating path, the movement of mining machinery within the mine was very difficult and costly. The most intensely folded ore was positioned near the top of the anticlinal structure where the mining was conducted. Mining was not done on the steeply dipping flanks of the anticline where the secondary folding may not have been as intense.

Salt Roof--During mining operations, a 5-foot salt roof was maintained above the workings to help prevent their closure. As shown on figure 2, high grade sylvite salts extend to within about 2.5 feet from the top of the K5 potash zone. In order to maximize the potassium output of the mine, ideally, all of the high grade ore should be removed. In practice, however, this could not be done, and at least 5 feet of roof salt, regardless of its potassium grade, was maintained between the bottom of the anhydrite-dolomite-shale (marker bed 4m), and the roof of the 8-foot high by 22-foot wide workings below. This 5-foot slab of roof salt served two functions in preventing or minimizing the rapid closure of the workings. First, anchoring 4-foot roof bolts within the 5-foot salt slab created a more competent unit, thus helping to prevent its collapse. Of secondary importance, the salt slab prevented moisture within the mine from wetting overlying shale units and thus causing them to swell and disintegrate.

Salt Movement--The movement and failure of the salt was also a major problem in the mine. It was estimated by Texasgulf personnel, that during the mining operations, 70 percent of closure within the workings was due to floor heaving. Failure also occurred by the spalling or breaking of pillars.

Mining in Salt (Sodium Chloride)

On occasion, workings were driven through pure halite as opposed to going through the sylvinite or the ore zone proper. The strength or competence of halite was reported to be much greater than that of the sylvinite and the workings in halite had less tendency to close. Workings in halite were much more stable, and roof bolts were not required to maintain the integrity of the roof.

Brine Pockets and Hydrated Salts

During mining operations, pockets of brine were only encountered within the M4 marker bed, above Salt 5. When encountered, the yield of brine was finite and minimal; a small amount would quickly drain from a cavity. Neither brine nor brine pockets were reported from within halite or sylvinite beds.

Halite and sylvite, found together as sylvinite, were the only salt minerals encountered within the Texas Gulf Sulfur mine. Neither carnallite ($Mg\ Cl_2\ KCl\ 3H_2O$) nor any other hydrated salts were encountered.

Hydrocarbons

Both crude oil and natural gas (methane) were encountered during mining operations. Like the brine, however, hydrocarbons were found only in the M4 marker bed lithologies and not within the sylvinite or halite beds. A methane explosion that reportedly killed a number of miners on July 31, 1963, occurred during the development of the incline from the bottom of the shaft to the ore zone proper. The source of the gas is suspected to have been from interbed 3, situated well above the K5 potash zone.

Temperature

The temperature of the mine workings was reported to be in the mid 90s (F); the temperature gradient to the working depth is about 7^{0} F/1000 feet.

Surface Subsidence

A network of level control stations was established and monitored during the mining of the Cane Creek Mine to detect and quantify any surface subsidence. No surface subsidence was detected.

Prior to solution mining

POTENTIAL MINING CONDITIONS AT GIBSON DOME

Gibson Dome, a potential site of the DOE's nuclear waste repository, is located about 25 miles south of the Cane Creek area (fig. 1). Stratigraphically, the repository would be positioned within Salt 6 about 200 to 300 feet below the ore zone of Salt 5 (fig. 4); access would be by a vertical shaft 3200 to 3300 feet in depth. The shaft would penetrate 2600 feet of non-evaporite lithologies, which make up four formations, before encountering the Paradox evaporites.

Based on the experiences of Texas Gulf Sulfur in developing the Cane Creek mine, as previously discussed, a number of considerations can be addressed concerning the development of a repository facility at the Gibson Dome site.

Depth

The total depth of the Cane Creek workings are of the same relative depth as those proposed at Gibson Dome, that is, about 3000 to 3500 feet. As such, the potential for salt movement within the workings exists, including spalling, roof collapse, and floor heaving. But, as workings within halite were observed to be much more stable at Cane Creek than those in the sylvinite or potash ore zone, these problems may be diminished or absent.

Mine Development

Unlike the workings in the potash mine, the repository workings, if properly positioned within the thick Salt 6 sequence, could be developed on a horizontal plane, penetrating through, rather than following, the secondary folding that might exist. Repository design would not be forced to follow ore grade. It could also be positioned stratigraphically to avoid both the potash horizons and non-evaporite interbeds. The shaft(s) would, of necessity, be required to penetrate the numerous interbeds and formations, above the repository horizon, which are composed of non-evaporite lithologies; attendent problems associated with these latter units would need to be addressed.

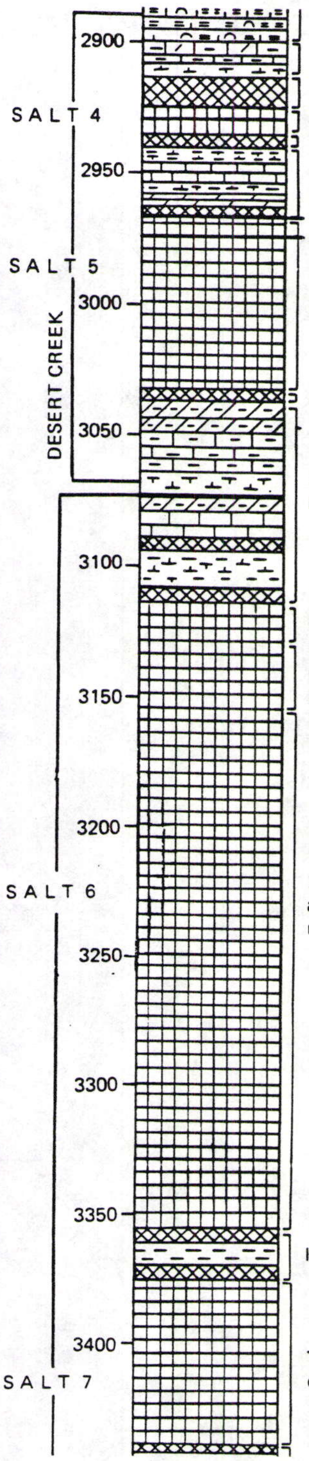

Figure 4. Lithologic Column showing the relationship between Salt Cycles 4 through 7. From Gibson Dome No. 1 Summary Log, Log 440, Woodward Clyde Consultants (1981).

Evaporite Lithologies

While the Cane Creek workings are confined almost exclusively to sylvinite and some halite, the repository workings proper would be confined to salt, exclusively. Salt, as used here, implies sodium chloride cut by thin, periodic bands of anhydrite (anhydrous calcium sulfate). The workings at Cane Creek did not encounter any hydrated salts. Carnallite, a hydrated potassium-magnesium-chloride, is present within the upper portion of Salt 6 at Gibson Dome, but would probably be stratigraphically above the proposed repository position. Non-hydrated sylvite as sylvinite is also present at Gibson Dome, but could be avoided in the repository design.

Brine Pockets

Brine pockets, though not identified during the drilling or examination of the Gibson Dome No. 1 core, may be present. It is expected, however, that, as at Cane Creek, they would be associated with the major non-evaporite interbeds, and not found within the salt itself. It is not expected that brine pockets would contain appreciable quantities or continual sources of liquid.

Hydrocarbons

Hydrocarbons, both oil and gas, were encountered during the Gibson Dome coring. It is anticipated that they would be encountered periodically during repository construction, associated with the non-evaporite or interbed units. Commercial quantities or sustained flows would not be expected. Major hydrocarbon production, in the vicinity of Gibson Dome, comes from the Leadville Formation some 5900 to 6300 feet in depth, and not from the salt interbeds of the Paradox Formation.

Temperature

The temperatures to be encountered within the proposed repository workings should be very similar to those found within the Cane Creek Mine. The maximum expected temperatures would be in the mid 90s (F).

Surface Subsidence

No surface subsidence was detected during the mining operations at Cane Creek, nor has any been detected since mining operations were halted and solution mining and solar evaporation activities were started. It is not expected that surface subsidence would occur at the proposed Gibson Dome repository site as the result of repository development.

SUMMARY

The main problems encountered while mining potash underground at the Texas Gulf Sulfur (Texasgulf, Inc.) potash mine included: 1) salt movement resulting in the slow but continual closure of workings, 2) the steep flanks and secondary folding associated with the anticline, 3) the need to leave and support a salt slab between the roof and the overlying M4 marker bed, and 4) the presence of methane. The presence of brine and oil, the temperature within the workings, and surface subsidence were not major problems in mining the potash. Mining within salt (halite) appeared to present far fewer problems than mining in sylvinite.

Possible problems anticipated with the construction of the proposed shafts and repository facilities at Gibson Dome would include salt movement at repository depth, warm working temperatures, and the presence of some methane in the interbeds. The greatest problems with methane would probably occur during the shaft construction phase of the work.

REFERENCE CITED

Evans, R., and Linn, K.O., 1970, Fold relationships within evaporites of the Cane Creek anticline, Utah *in* Third Symposium on Salt: The Northern Ohio Geological Society, v. 1, p. 286-297.